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SCIENTIFIC STATESMANSHIP IN AIR POLLUTION CONTROL

Barry Commoner

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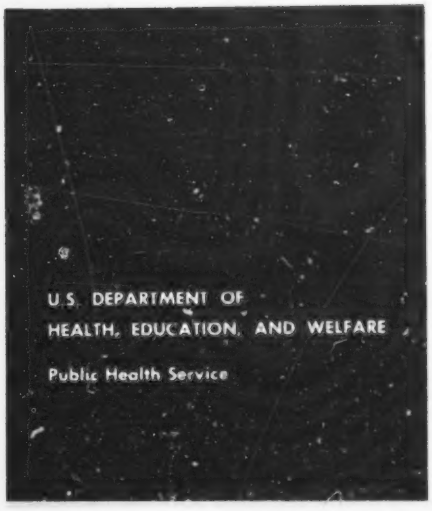

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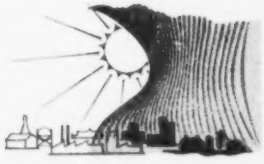

This pamphlet was originally a speech presented by Barry Commoner, Ph. D., Chairman, Committeee on Science in the Promotion of Human Welfare, American Association for the Advancement of Science, and Professor of Plant Physiology, Washington University, St. Louis, Missouri. It was delivered at the National Conference on Air Pollution in December 1962.

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Scientific Statesmanship in Air Pollution Control

That science should require the guidance of statesmanship and statesmanship the discipline of science is a special mark of these disjointed times. Science, which is at its source an encounter of a single mind with the stern reality of nature, would appear to have no cause to weigh the wisdom of its inevitable course. The affairs of state, which are guided by values that are remote from natural law, have seemingly little need for the discipline of science.

Why then have science and statesmanship become—as they now are—so closely intertwined? Seventy years ago Pasteur could advise students, "Whatever your career may be, do not let yourselves be discouraged by the sadness of certain hours that pass our nations. Live in the serene peace of laboratories and libraries. . . ." Why has the serenity of the laboratories been swept away by intruding social problems? Why has the discipline of science now intervened in the councils of state? Where in this tangled design lies the duty of the scientist to society, to science, to himself?

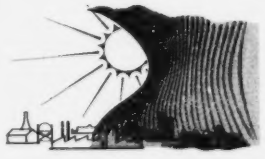
The answer, I believe, lies in understanding the paradoxical effects of scientific progress on the welfare of man. Nowhere is this paradox more acutely revealed than in the problem of environmental pollution.

ENVIRONMENTAL POLLUTION: A WARNING

This conference is concerned with finding ways to free the air of its growing burden of pollution. That such a conference should be necessary at this time sharply illuminates the conflicting effects of science on society.

We are living in a time of astonishing scientific progress. Scientific research has become a powerful tool for analyzing the natural world, from the depths of the earth to the outer reaches of space. Evidence of its success—the wonderful harvest of technological applications—is all around us: space vehicles, nuclear power, numerous new synthetic chemicals, great improvements in the practice of agriculture, medical advances which have significantly increased the length and usefulness of human life.

But we also see some sharp contrasts. At this moment, in some other city, a group may be meeting to consider how to provide air for the first human inhabitants of the moon. Yet, we are meeting here because we have not yet learned how to manage our lives without fouling the air that man must continue to breathe on Mother Earth. We hear of masterful schemes for using nuclear explosions to extract pure water from the moon; but in some American cities the water that flows from the tap is no longer an



entirely palatable fluid, and the householder will find it instead in bottles on the market shelf. Science in 1962 is radiant with far-flung success, and—it would seem—clouded by growing difficulties in providing for the necessities of life.

Why should this be so? Is the pollution of the air that we breathe and of the water that we drink only a passing imperfection in human society? Or is it a more serious matter—a warning that despite all the new powers of science, or perhaps because of them, we can no longer exert a sufficient mastery of our environment?

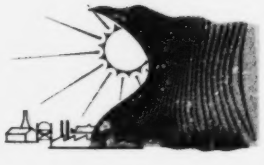
PROGRESS PRODUCES PROBLEMS

Air pollution is only one of a number of new and unwelcome problems: the pollution of water, not only by human waste but also by synthetic chemicals; unwanted loss of animals and plants, and possible human health hazards from widespread dissemination of pesticides and herbicides; confusion about tolerable levels of chemical food additives; the hazards of radioactive wastes from nuclear reactors and of fallout from nuclear explosions.

These problems have in common a set of relationships to science, and a troublesome involvement in public controversy.

(1) Each of these difficulties is a result of scientific and technological progress. The new synthetic chemicals, which are the fruits of remarkable advances in chemical technology since World War II, appear in a multitude of useful forms—but also as pollutants of air and water. The development, just 20 years ago, of self-sustained nuclear reactions has given us not only new weapons and sources of power—but radioactive debris as well.

(2) Many of these problems seem to crop up unexpectedly. The photochemical conversion of hydrocarbons, which produces smog, was discovered not in a chemical laboratory but in the air over Los Angeles, long after the technological practices that disseminated the hydrocarbons were well entrenched in our economic life. The resistance of synthetic detergents to bacterial degradation was apparently discovered only when the resultant accumulation in water supplies became noticeable, by which time detergents were already a common household item. The absorption of certain radioisotopes in the human body became known only some years after the establishment of massive programs of nuclear testing. All of these problems have been imposed on us—sometimes with a considerable surprise—well after the causative activity was in full swing.



(3) It is also characteristic of the pollution problem—whether of air, water, or food—that the most serious difficulties arise in the realm of biology. Unfortunately, the processes which are the biological targets of modern pollutants are singularly intractable to scientific analysis. The hazards from certain air pollutants and from radioactive wastes are due to the possibility that they

may induce cancers. The origin of cancerous growth and the mode of action of chemicals and radiation in promoting it remain, of course, one of the great unsolved problems of modern science. The mechanism of action of DDT on insects, and its effects on mammals, are poorly understood. Despite very considerable investigation, the basic mechanism of plant growth, with which the new synthetic herbicides interact, remains unknown.

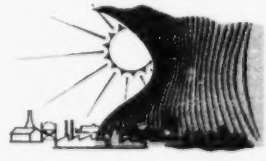
There is, then, a remarkable incongruity between the two ways in which science enters into modern pollution problems. On the one hand, scientific research has produced chemical and radioactive pollutants hitherto absent from the surface of the earth. But at the same time modern science appears to be poorly prepared to understand the particular biological damage that these new materials may cause.

VARYING DEGREES OF CHANGE

The recent history of the sciences reveals some of the reasons for these conflicting consequences of scientific progress. Nuclear technology results from laboratory experiments on fission reactions first reported some 30 years ago; and behind this discovery lay the great revolution in our basic understanding of the structure of matter which took place at the turn of the century. One reason for the remarkable growth in the number of synthetic organic chemicals is that chemical engineering, which was once an empirical technology, has now become firmly based on the theoretical knowledge of the mechanisms of chemical reactions—which is in turn elucidated by the new physical theories.

While physics and chemistry and their technological offshoots have been radically reformed by the theoretical revolution that began about 50 years ago, biology—or at least those of its areas which are related to the effects of the new pollutants—has proven to be considerably more resistant to change. Anyone who wishes to be convinced of this need only compare the present textbooks of physics, chemistry, and biology with those of, let us say, 25 years ago. A 25-year-old text in organic chemistry is a densely packed summary of empirical knowledge about a vast array of organic reactions; but the modern text is a logically organized consideration of the electronic structures of atoms and molecules, and describes how this knowledge can guide the chemist in controlling reactions and in synthesizing new molecules to specification. On the other hand, current textbook discussions of the physiology of plant growth, or of the mechanism of carcinogenesis, while they may be couched in the language of present fads in experimentation, lead to the same final answer offered by a 25-year-old text: the mechanism of growth, whether of plants or of neoplasms, remains unknown.

If basic theories of physics had not attained their present power, we would not be confronted with massive dissemination of man-made radioactive isotopes and synthetic chemicals. If biological



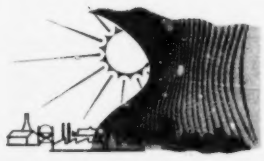
theory had by now become sufficiently advanced to master the problems of normal and neoplastic growth, we might be better prepared to cope with these modern pollutants. We are in difficulty because of a wide disparity between the present state of the physical and biological sciences.

Trouble arises because the separation of the laws of Nature among the different sciences is, of course, a human conceit; Nature itself is an integrated whole. We classify nuclear explosions as experiments in physics, representing a step in a progression of growing knowledge about nuclear reactions. Yet every nuclear explosion is also a vast experiment in biology, but one which is only remotely connected with earlier biological research. Thus, modern physics was ready to detect strontium 90, to analyze its nuclear structure, and to understand its origin in the fission reaction. In contrast, modern biology was quite unprepared for the entry of strontium 90 on the scene, for until the fallout problem revealed the necessity for such studies, normal strontium metabolism was an almost completely neglected subject.

UNEXPECTED RESULTS

The same pattern can be found in most of our pollution problems. The development of highly efficient new insecticides reflects an impressive mastery of chemical synthesis and of methods of dissemination. But the intrusion of a new insecticide into the biosphere may lead to rude surprises.

The current debate about insecticides reminds me of my own education in this matter. During World War II, I served as project officer in the Navy's development of aircraft dispersal of DDT—which proved to be of great importance in the Pacific battles. The project made meticulous studies of aerosol production, aerodynamic distribution, insect kill, meteorological effects, and problems of flying tactics. Toward the end of our work, when we were justifiably proud of a system ready for fleet operations, we received a request for help from an experimental rocket station on a strip of island beach off the New Jersey coast. Urgent experimental work was severely hampered by flies; would the Navy please get rid of them? We doused the island with DDT. Within half a day the beach became a flyless paradise and the rocketeers went about their work with renewed vigor. But a week later they were on the telephone again. A mysterious epidemic had littered their beach with tons of decaying fish—and all the flies in New Jersey had come to enjoy the fun. That is how I learned that DDT kills fish.



I believe that the history of modern pollution problems shows that most of them result from the same general fault. *We have been massively intervening in the natural world, without being aware of many of the biological consequences until the act has been performed, and its effects—which are difficult to understand, and sometimes irreversible—are upon us.* We can produce

and widely disseminate radioisotopes, but do not fully comprehend how they will affect life. We can synthesize and disseminate a marvelous variety of synthetic chemicals before we have sufficiently mastered what they will do in a living organism. Like that of the sorcerer's apprentice, our education is dangerously incomplete.

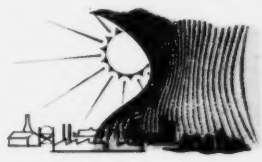
It will be argued, I know, that this is nothing new—that it is the grand purpose of science to move into unknown territory, to explore and to discover. It can be said that similar risks have been taken before, and that science and technology cannot move forward without taking some risks.

But these arguments overlook an important element which is new. In the past, the risks taken in the name of scientific progress—boiler explosions on the first riverboats, or the early experiments with X-rays—were restricted to a small place and a brief time. But the processes which we now strive to master are neither local nor brief in their effects. Air pollution covers vast urban areas. Fallout is worldwide. Synthetic chemicals may remain in the soil for years. Radioactive pollutants now in the biosphere will be found there for generations, and in the case of carbon 14 for thousands of years. The size and persistence of possible errors have grown with the expanding power of modern science.

One can also argue that the hazards of modern pollutants are small compared to the dangers associated with other human enterprises—such as automotive traffic. But no estimate of the actual harm that may be done by smog, fallout, or chemical residues can obscure the sober realization that the risk was taken before it was fully understood. The importance of these issues to science lies not so much in the technical difficulty of estimating the associated hazards, but in that they warn of an incipient abdication of one of the major duties of science—prediction and control of human interventions into nature. The true measure of the danger is not represented by the present hazard, but by the disasters that will surely be visited upon us if we dare to enter the new age of science that lies before us without repairing this basic fault in the scientific enterprise.

THE SCIENTIST AND SOCIAL PROBLEMS

Having examined some of the scientific difficulties associated with modern pollution, what can be said about the scientist's relationship to the social problems that follow in their wake? Each of the issues that I have mentioned has been marked by public confusion and controversy, severe legislative debate, and enormous administrative difficulties. They represent a veritable jungle in which science, industry, economics, local politics, foreign affairs, religion, and morality intermix in uproarious confusion. No scientist who enjoys the quiet of his laboratory or the reasonableness and objectivity of scientific discourse is likely to



walk into this wilderness voluntarily—or to emerge from it unscathed.

That thousands of scientists—including those present at this conference—have been willing to devote their skill and energy to bring order out of this chaos reflects, I believe, the serious impact which these problems have had on the inner life of science.

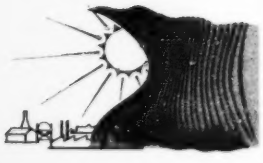
In no area has there been a more serious concentration of effort than in the problem of low-level radiation from fallout, particularly under the aegis of the U.S. Public Health Service. The recent history of this issue provides a clear picture of how the social problems emerge from scientific ones and can illuminate some general aspects of environmental pollution as a whole.

Until a few years ago the possible effects of low-level radiation were guided by the assumption that doses below a particular level would cause no discernible medical effects. Since the estimation of the threshold dose is a purely scientific matter, it was possible for groups of scientists, such as the International Committee for Radiation Protection, to deliberate on the problem and recommend some permissible level of radiation which ought not to be exceeded if medical hazard is to be avoided.

However, evidence has since accumulated which suggests that one cannot safely assume any threshold in the relationship between radiation dosage and the resultant biological effects. Consequently, beginning in 1958, scientific agencies charged with the responsibility of setting radiation protection standards uniformly adopted the assumption that any increment in radiation exposure, however slight, is accompanied by a comparable increase in the risk of medically undesirable effects. If this is the case, and there is no absolutely safe limit, how can one determine what dosage is to be tolerated?

This judgment requires a balance between the risk associated with a given dosage and some possibly countervailing benefit. The agency now responsible for setting radiation standards in the United States, the Federal Radiation Council, has explicitly stated this position.

> If . . . beneficial uses were fully exploited without regard to radiation protection, the resulting biological risk might well be considered too great. Reducing the risk to zero would virtually eliminate any radiation use, and result in the loss of all possible benefits. It is therefore necessary to strike some balance between maximum use and zero risk. In establishing radiation protection standards, the balancing of risk and benefit is a decision involving medical, social, economic, political, and other factors. Such a balance cannot be made on the basis of a precise mathematical formula but must be a matter of informed judgment.



This approach is, I believe, equally applicable to most other pollution problems. Since they are all large-scale effects and influence a wide variety of living organisms, on statistical grounds alone, it is probable that the smallest detectable pollutant level represents some hazard, however slight, and that the risk will increase roughly with the level.

What is the proper role of the scientist in such a judgment? What scientific procedure can determine, for example, whether the benefits to the national interest of nuclear testing outweigh the hazards of fallout? What is the "importance" of fallout, determined scientifically? Some scientists have stated, with the full dignity of their scientific preeminence, that the fallout hazard while not zero is "trivial." Nevertheless I have seen a minister, upon learning for the first time that acts deliberately performed by his own nation were possibly endangering a few lives in distant lands and a future time, become so incensed at this violation of the Biblical injunction against the poisoning of wells as to make immediate determination to oppose nuclear testing. What science can gage the relative validity of these conflicting responses to the same facts?

How can scientific method determine whether the proponents of urban superhighways or those who complain about the resultant smog are in the right? What scientific principle can tell us how to make the choice—forced upon us by the insecticide problem—between the shade of the elm tree and the song of the robin?

Stated in this form, the answers to these questions become apparent. Certainly science can validly describe what is known about the information to be gained from a nuclear experiment, the economic value of a highway, or the hazard of radioactive contamination or of smog. The statement will usually be hedged with uncertainty, and the proper answer may sometimes be, "We don't know"; but in any case these separate questions do belong within the realm of science. However, the choice of the balance point between benefit and hazard is a value judgment; it is based on ideas of social good, on morality or religion—not on science.

There can be no scientific agreement on such judgments; answers will differ according to religious or political outlook. Scientists who present their own judgments on these matters as though they were scientific evaluations are simply forcing a disagreement which can never be resolved by scientific means. Such a disagreement appears as a perplexing exception to scientists' vaunted skill at winning truth. The citizen will be driven to ask a question which is now heard with increasing frequency, "How do we know which scientist is telling the truth?" This doubt can only impair confidence in the validity of the excellent methods which science possesses for getting at the truth—about scientific questions.

In the "informed judgment" of which the Federal Radiation Council so properly speaks, the scientist can justly claim to be "informed," but in my opinion he can make no valid claim for a special competence in "judgment." To act otherwise is to corrupt the meaning of science and to undermine its usefulness to society.

I believe that once the scientific evidence has been stated, or its absence made clear, the establishment of a level of tolerance for a modern pollutant is a social problem and must be resolved

by social processes. In these processes the scientist has one vote and no claim to leadership beyond that given to any person who has the gift of moving his fellow men. But the government official, whose task is to make these judgments, and the citizen—who must provide the social ideology which guides administrative decision—require for these purposes the necessary facts, and the relevant evaluations. Where these are matters of science, the scientist as the custodian of this knowledge has a profound duty to impart as much of it as he can to his fellow citizens. But in doing so he must guard against false pretensions, and avoid claiming for science that which belongs to the conscience.

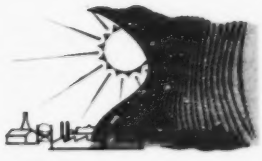
THE RISK OF SECRECY

In this discussion I have tried to show that the scientific and social difficulties that encumber the problems of modern pollution reflect a basic flaw in the present relations between science and social processes. We have not yet learned how to apply modern science in a manner which is consistent with its enormous power and its present inadequacies. We have not yet learned to discern in these complex problems the proper roles of scientific knowledge and social judgment.

It seems to me that until effective means for dealing with these questions are developed, we will be in continuous danger from unanticipated and poorly understood hazards, which will grow in magnitude as the power of science advances. If we are to live securely with the new discoveries and inventions of modern science, we shall need as well new inventions to govern the relation between science and society.

Although the task of developing such new procedures is formidable, there are some useful guidelines in our recent experience. I believe, for example, that the scientific community might have done a great deal to mitigate the present conflicts about insecticides, fallout, and smog, if it had applied the customary principles of scientific inquiry to these problems at the right time. Clearly, the decisive time to evaluate the risks associated with a new technological program is before it is put into effect. The longer such an evaluation is delayed, the less its value to society, for once the process has become embedded in a vast economic or political commitment, it may be nearly impossible to alter.

In this task, the scientist's duty is plain, for it is no different from his responsibilities toward the development of all scientific knowledge. The scientists must examine all the evidence and summarize it in a statement of what is known, what is assumed, what is doubtful, and what is possibly erroneous. He must also describe the limits of the relevant knowledge, for these will reveal what new knowledge is needed and indicate when a proposed technological application may expose us to the dangers of acting in ignorance.



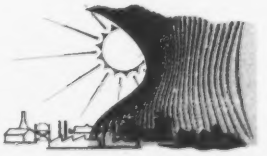
I make this proposal quite conscious of the obstacles which may block scientific evaluation of risks and benefits *in advance* of a proposed technological innovation. Perhaps the most serious of these is that the government's military or political necessities, or an industry's competitive position, may dictate secrecy. A recent scholarly review on the toxicology of herbicides, written to enlighten the scientific community and to encourage new work on this difficult problem states in its opening paragraph: "Many of the toxicological data underlying assessment of the risks involved by using them [weed killers] in practice originate from confidential, nonpublished reports placed at the disposal of the authorities concerned. Such data have not been included in the present survey."

We pay a steep price for this kind of secrecy. Scientific knowledge is not created whole in one man's mind, or even in the deliberations of a committee. Each separate scientific analysis yields an approximate result and inevitably contains some errors and omissions. Science gets at the truth by a continuous process of self-correction, which remedies omission and corrects errors. In this process, the key elements are open disclosure of results, their general dissemination in the community of scientists, and the resultant verification, criticism, and correction. Anything that blocks this process will hamper the approach to the truth. The basic difficulty with secrecy in science is that mistakes made in secret will persist. Every attempt to keep a scientific problem secret is paid for in the most expensive currency in the world—knowledge.

Science has great power to serve society. But it cannot properly perform this function if deprived of access to the facts. *The time has come, I believe, for government and industry alike to consider with great care the relative benefits and risks associated with the avoidance of full and early disclosure of scientific evidence relevant to large-scale processes that may result in environmental pollution.* I believe that the present confusion and controversy about these problems are part of the price paid for secrecy, and in my opinion the price is uneconomical for industry and the Nation alike.

OPEN SCIENTIFIC INQUIRY

It should be possible, I believe, to find ways of bringing the full force of scientific knowledge—which is something that only the total community of scientists possesses—to bear on these problems. An important first step might be the organization, *in advance* of any large-scale technological innovation of an open *Scientific Inquiry* to consider the state of knowledge about the associated benefits and hazards. This, or any other, procedure must be established soon, for new proposals are being advanced constantly. Suggestions have been made for the use of mutagenic (and there-



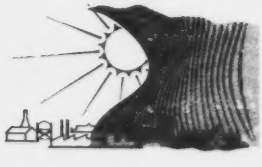
fore also carcinogenic) chemicals for controlling insects by inducing sterilization. This may entail new biological hazards. Surely the scientific community can arrange to discuss these openly and widely before the proposal is put into effect.

If we develop such new means for orderly consideration of the problems of environmental pollution, they will have a much wider usefulness. Consider, for example, a proposal which is about to be considered by the Government to develop airliners designed to fly at two or three times the speed of sound. Such an airliner flying across the United States will produce in a zone 25 miles wide a continuous series of intense sonic booms. Where in our social processes have we weighed whatever benefit is involved in traveling from coast to coast in 2 hours against the hazards associated with the effects of sonic booms?

I can report that in my own city the resolution of this balance has taken a rather curious form. For a period of weeks earlier this year, St. Louis endured sonic booms, sometimes at hourly intervals and often in the small hours of the night. The hazards were clear: the Air Force was besieged with claims for broken windows, cracked walls, and fallen ceilings. Citizens complained about children awakened or frightened while awake. Protests began to mount, but not enough to counterbalance the military benefits of the flights—for they continued. I offer as a possibly useful piece of evidence regarding the weight to be accorded such benefits and hazards that when two gazelles in the St. Louis Zoo became so startled one night as to die in the ensuing upset—the flights were abruptly halted.

Is this the proper measure of the sonic boom hazard? Do we know enough about the number of babies that will be awakened every night by a supersonic airliner to make an "informed judgment" on its social usefulness? Do we really understand the physiological effects of the rather sudden compression associated with a sonic boom to be capable of evaluating the basic medical hazard? If these factors are not yet understood, how can a government agency, or the citizen, make the necessary informed judgment? If we invest nearly $1 billion in an airliner before we have determined whether its social usefulness will outweigh its social harm, will the step become thereby an irreversible one? Surely we need a scientific inquiry into this project before it is committed to action.

THE CITIZEN'S ROLE



But no amount of advance information will suffice if it is not in the hands of those who must serve as the final arbiters of social good—the citizens. Can this be done? Can we expect our citizens to comprehend the benefits and hazards of nuclear reactions? Can they understand the relationship between hydrocarbons, sunlight, and smog?

I am convinced that this is possible—providing citizens accept the duty to learn, and scientists accept the duty to teach. The task will not be an easy one, but I believe that we have the resources at hand. This vast educational task is not one that ought to be delegated alone to those scientists who have already devoted their professional energies to the problems of environmental pollution. These problems are so large and range so widely across the spectrum of science, that all scientists, regardless of their immediate professional interests, are intimately concerned with them. Pollution of the environment touches the work of every meteorologist, ecologist, or chemist; the possible hazards are of interest to every biochemist and to every specialist in the biological and medical sciences.

Knowledge of these problems, and the willingness to explain them to the public, should, I believe, be the responsibility of each of the more than 100,000 scientists of this Nation. Given this army of teachers, which is available to almost every community in the country, this educational task can surely be accomplished. Already in a number of cities, groups of scientists are educating their fellow citizens about radiation problems; I believe that given adequate support and the broad participation of all scientists, such groups should be capable of expanding their work to encompass the broad range of problems of environmental pollution.

Nor should we be discouraged by the difficulties and disagreements that now burden these problems. The attention which these controveries generate can serve as a timely warning that we must learn—now, before the hazards of unwitting action overtake us—how to live in the new world that science is creating. Science has placed enormous new powers at the hand of man. If we accept with these powers the new responsibilities which must govern their use, science can serve its true goal—*the welfare of man.*

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